

Mirror Images: Marginal Product and Marginal Cost

Most of the activities in this unit concern a firm's costs of production. You will learn about a firm's costs of producing a given amount of its product—*total fixed cost (TFC)*, *total variable cost (TVC)*, and *total cost (TC)*. You also will work with the firm's costs of a typical (average) unit of output—*average fixed cost (AFC)*, *average variable cost (AVC)*, and *average total cost (ATC)*. The most important measure of a firm's cost is *marginal cost (MC)* because it shows the change in the firm's total cost when it produces one more unit of output. You will not be surprised to find that the cost of producing output is based on the productivity of the firm. If a firm is highly productive, that means it is producing a lot of output from a given amount of resources, thus reducing its costs of production. Firms that are inefficient will have high production costs and be at a competitive disadvantage. Because high productivity implies low cost, economists treat a firm's cost measures as mirror images of its productivity measures.

A firm makes production decisions in two time horizons. The "short run" is a period of time in which the amount of some key factor of production, often capital, is fixed. Other factors, such as labor, are variable because the firm can increase or decrease the amount of these resources in the short run. In the "long run," all resources are variable and can be increased or decreased by the firm.

There are three measures of the productivity of a firm.

1. The firm's *total physical product* or *total output (Q)* is how many units of its good or service the firm produces in a specified period of time. If a firm produces 100 units per week, we express this as $Q = 100$.
2. The firm's *average physical product (APP)* shows how many units of output are produced by an average unit of labor (the variable resource). If the firm uses five units of labor (L) to produce 100 units of output each week, we say $APP = Q/L = 100/5 = 20$ units of output.
3. The firm's *marginal physical product (MPP)* tells us the change in total product when the firm adds an extra unit of labor to its fixed stock of capital. If, as a result of adding a sixth unit of labor the firm's total output increases from 100 units to 114 units, then the MPP of the sixth labor unit is +14 units: $MPP = \Delta Q / \Delta L = +14 / +1 = +14$.

! Student Alert: The terms *average physical product* and *average product* mean the same thing. Also, *marginal physical product* is the same as *marginal product*. Some textbooks use APP and MPP, while others use AP and MP. But you cannot use "average" terms interchangeably with "marginal" terms!

The key productivity principle in the short run is the "law of diminishing marginal productivity" (also called the law of diminishing marginal returns). Assume a firm operates in the short run with a fixed amount of capital and with labor as its variable resource. The law of diminishing marginal productivity states that as the firm adds more labor units to its fixed stock of capital, eventually the MPP from an extra unit of labor will diminish.

Part A: The Productivity Measures of a Firm

Table 3-2.1 is a short-run production chart showing how the productivity of the firm changes as it adds additional units of labor to its fixed stock of capital. Assume the data refer to the firm's productivity in a one-week period.

1. Complete Table 3-2.1. Some data are already included in the chart. Put the values of MPP at the new labor level. For example, when the firm increases its labor from one to two units per week, its total output increases by 15 units. Write "+15" at L = 2 in the MPP column.



Table 3-2.1

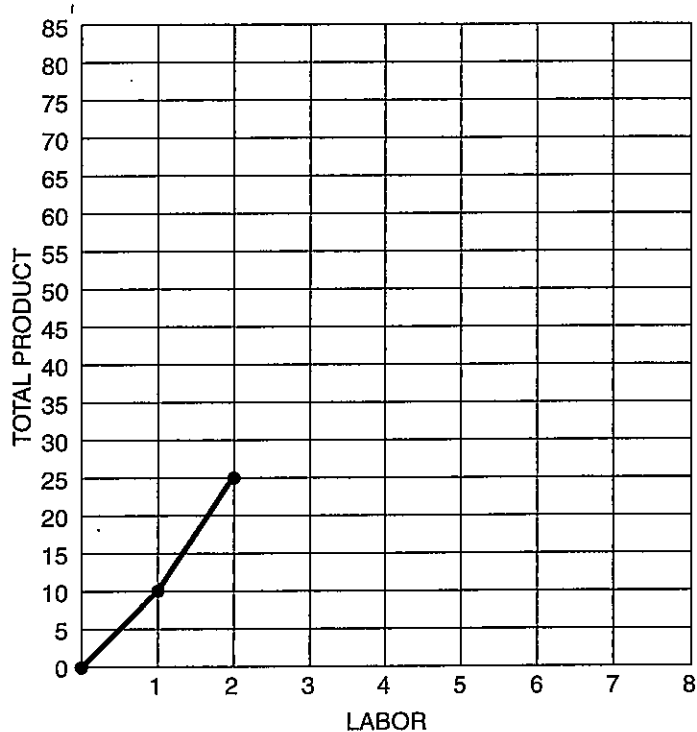
The Three Productivity Measures of a Firm

L	Q	MPP = $\Delta Q / \Delta L$	APP = Q / L
0	0	—	—
1	10		10.0
2	25	+15	
3	36		
4	46		11.5
5	55	+9	
6	63		
7	63		9.0
8	60	-3	

2. When you have completed Table 3-2.1, plot the L and Q data in Figure 3-2.1. (The first two combinations are plotted for you already.) This Q curve shows how much total output the firm produces with different amounts of labor. Note that the firm's total product increases as it adds more labor, but eventually the total product declines if the firm adds too many labor units on its limited amount of equipment.



Figure 3-2.1
Total Product

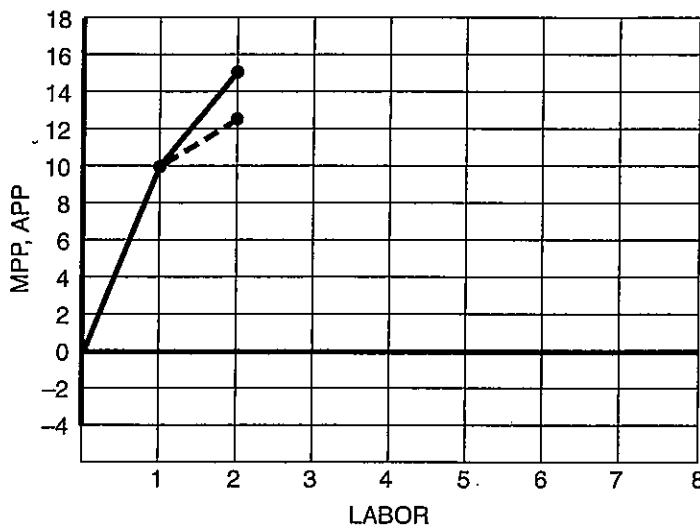


3. Now plot the L, MPP, and APP data in Figure 3-2.2. You can connect the MPP points with a solid line and the APP points with a dotted line. (Some combinations are plotted for you already.) Plot the values of MPP at the new labor level. For example, put a dot on the graph at the combination of $L = 2$ and $MPP = +15$ since the MPP resulting from adding the second labor unit is 15 units of output. Note that both MPP and APP increase initially but then decrease as the firm adds more units of labor.



Figure 3-2.2

Marginal Physical Product and Average Physical Product



4. Diminishing marginal productivity sets in with the addition of the _____ labor unit.
5. The average physical product continues to increase as long as the marginal physical product is (greater than / equal to / less than) the average physical product.
6. Can the average physical product of labor be negative? Why?

7. Can the marginal physical product of labor be negative? Why?
8. Total product increases as the firm adds units of labor as long as the marginal physical product is (*positive / zero / negative*).
9. Although our graphs have no information about the price of the good or the price of labor, we can conclude that the firm will not want to hire a unit of labor for which marginal physical product is (*diminishing / negative*). Explain your answer.
10. What is the relationship between marginal physical product and total product?
11. What is the relationship between marginal physical product and average physical product?

Part B: Productivity and Cost: A Mirror View of Each Other

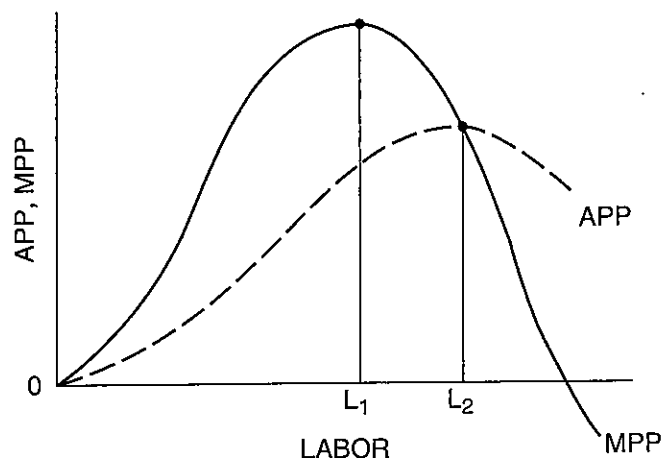
As you work with productivity and cost graphs, note how the axes are labeled. The productivity graphs typically have L on the horizontal axis because that is the variable resource that the firm changes in order to alter its level of total output. The vertical axis has some measure of productivity (such as Q or APP). There are no dollar signs on a productivity graph because such graphs are not dealing with revenue or cost. The cost graphs always have total output or total physical product (Q) on the horizontal axis because costs are expressed in relation to the Q of the firm. Cost graphs always have a dollar-measured concept on the vertical axis (such as total cost [TC] or marginal cost [MC]).

Figure 3-2.3 shows the relationship between a firm's MPP and APP . The graph assumes MPP initially increases as the firm adds labor units due to specialization of labor on the firm's equipment. Eventually diminishing marginal productivity sets in, which means that at some point APP also will decline as more labor units are added.



Figure 3-2.3

Marginal Physical Product and Average Physical Product



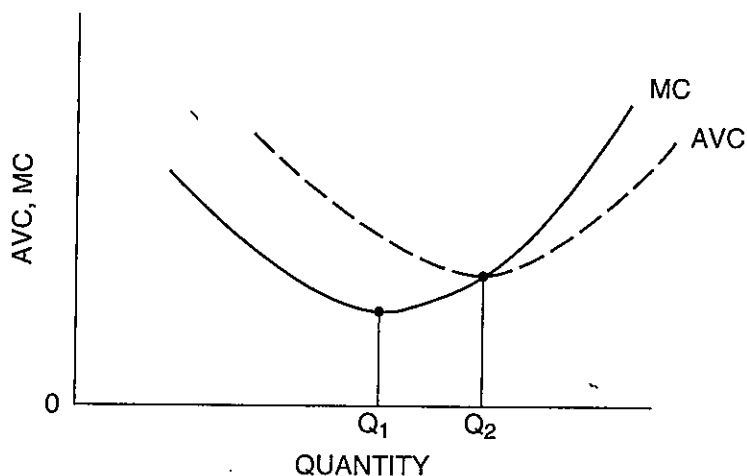
12. Diminishing marginal productivity sets in at (L_1 / L_2) labor units.
13. APP increases as long as MPP is (*greater than / equal to / less than*) APP.
14. APP decreases as long as MPP is (*greater than / equal to / less than*) APP.
15. Why is APP maximized at L_2 labor units?
16. "If MPP is diminishing, then APP must also be diminishing." Is this a correct statement? Why?

Figure 3-2.4 shows the relationship between a firm's MC and AVC: $AVC = TVC/Q$. If the firm has L as its only variable resource, then AVC represents the labor cost per unit of output. Suppose a firm pays each of its 10 workers a daily wage of \$80 and produces a Q of 400 units. Its TVC is $\$800 = (10)(\$80)$, and its AVC is $\$2 = \$800/400$. Each of its 400 units has a labor cost component of \$2.



Figure 3-2.4

Marginal Cost and Average Variable Cost

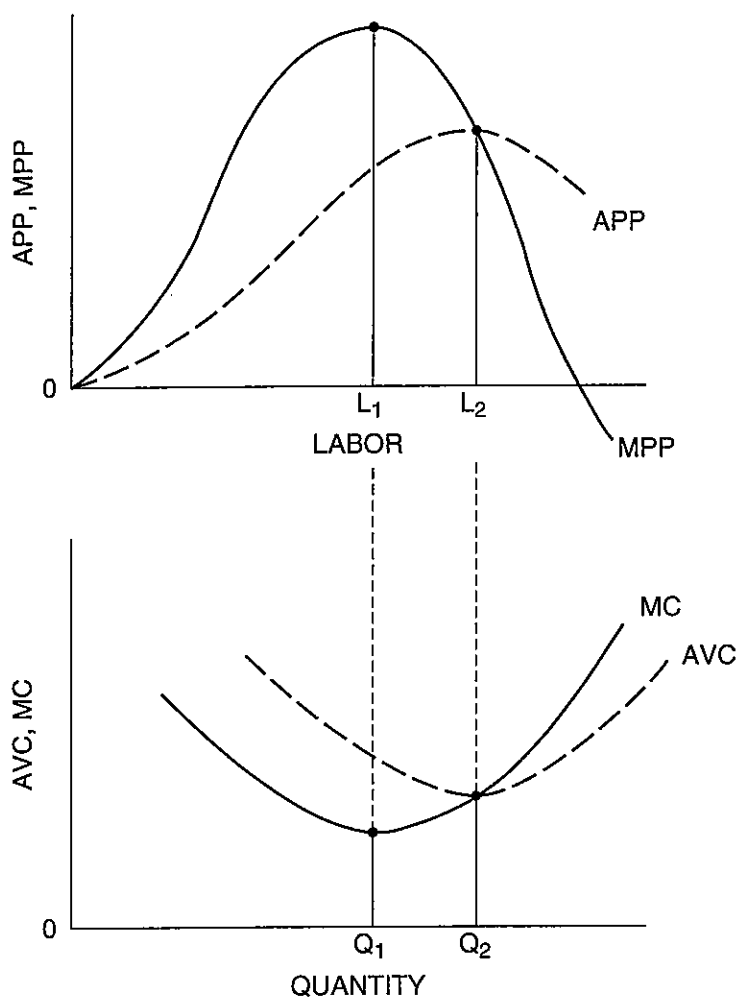


17. AVC decreases as long as MC is (*greater than / equal to / less than*) AVC.
18. AVC increases as long as MC is (*greater than / equal to / less than*) AVC.
19. Why is AVC minimized at Q_2 units of output?
20. "If MC is increasing, then AVC must also be increasing." Is this a correct statement? Why?



Figure 3-2.5

Mirror Image of Productivity and Cost Measures



The productivity of a firm is the basis of its cost. A firm wants to be highly productive in order to keep its costs low. Refer to Figure 3-2.5 to answer the following questions based on a firm's productivity and cost measures. Assume outputs Q_1 and Q_2 are produced by this firm when it uses L_1 and L_2 labor units, respectively.

21. As long as the MPP of labor is increasing, the MC of producing extra units of output will (increase / not change / decrease).

22. As long as the MPP of labor is decreasing, the MC of producing extra units of output will *(increase / not change / decrease)*.
23. The MC of producing extra units of output will be minimized when the MPP of labor is _____.
24. As long as the APP of labor is increasing, the AVC of producing output will *(increase / not change / decrease)*.
25. As long as the APP of labor is decreasing, the AVC of producing output will *(increase / not change / decrease)*.
26. The AVC of producing output will be minimized when the APP of labor is _____.

Understanding the Different Cost Measures of a Firm

Part A: Different Meanings of the Word “Profit”

Economists assume the goal of a firm is to maximize its total profit. This sounds like an easy goal to understand, but the economist’s view of profit is different from that of an accountant. Let’s use a short story about Pat to illustrate the differences. First, we must define two categories of cost. An *explicit cost* is an expenditure by the firm; it could be a payment for items such as wages, rent, or advertising. An *implicit cost* is the opportunity cost of an entrepreneur using his/her own resource in the company.

An economic short story: Pat is a banker who earned an annual salary of \$50,000 last year. She invested a total of \$100,000 of her own money in various savings assets, which gave her interest income of \$6,000. Pat also owns a small building, which she leased to someone last year for \$14,000. But now Pat decides she wants to leave banking and set up her own landscaping company. Rather than borrowing money to buy new equipment, she uses her \$100,000 in savings to buy it. She also decides to stop leasing her building so she can use it for her new enterprise. In her first year of landscaping, Pat brings in total revenue of \$300,000. She spends \$220,000 for such things as her equipment, workers, supplies, and insurance.

1. An accountant defines total profit to be total revenue minus explicit costs. Pat’s *accounting profit* from her landscaping company is \$_____ this year.
2. In addition to explicit costs, an economist considers implicit costs as well. This year, Pat’s *economic profit* from her landscaping business is \$_____.
3. Another type of profit is called *normal profit*. It recognizes that Pat should “pay herself” for using her resources in her own company. Her normal profit, which is equal to her implicit costs, indicates the income Pat’s resources would have earned had they been used in their best alternative occupations. Pat’s normal profit is \$_____.
4. If Pat’s total revenue from her landscaping business is only \$280,000, what would be the values of the different measures of profit?
 - (A) Accounting profit = \$_____
 - (B) Economic profit = \$_____
 - (C) Normal profit = \$_____

Part B: The Seven Measures of a Firm's Short-Run Costs

The Morton Boat Company produces the very popular Jazzy Johnboat, which is desired by many fishermen and fisherwomen. Assume the firm operates in the short run with a fixed amount of equipment (capital) and views labor as its only variable resource. If it wants to produce more output, it will add more units of labor to its stock of equipment. Of course, the firm will have to pay its workers and also the owners of its capital, which means its total cost will increase as it produces more boats. Table 3-3.1 defines the seven cost measures the Morton Boat Company must consider.



Table 3-3.1

The Seven Short-Run Cost Measures of a Firm

Cost measure	What it means	How to calculate it
Total fixed cost (TFC)	All costs that do not change when output changes. TFC is a constant amount at all Q levels.	TFC = total cost of all fixed factors of production $TFC = Q \times AFC$
Total variable cost (TVC)	All costs that do change when output changes. TVC gets bigger as Q increases because the firm needs more labor to make more output.	TVC = total cost of all variable factors of production $TVC = Q \times AVC$
Total cost (TC)	All costs at a given output level. TC is the sum of TFC and TVC. TC increases as the level of output increases.	$TC = TFC + TVC$ $TC = Q \times ATC$
Average fixed cost (AFC)	Fixed cost (capital cost) per unit of output. AFC always falls as Q rises since TFC is a constant value.	$AFC = TFC/Q$
Average variable cost (AVC)	Variable cost (labor cost) per unit of output. AVC falls at first, and then rises as Q increases.	$AVC = TVC/Q$
Average total cost (ATC)	Total cost per unit of output. It is the sum of AFC and AVC. ATC falls at first, and then rises as Q increases.	$ATC = TC/Q$ $ATC = AFC + AVC$
Marginal cost (MC)	Change in the firm's TC when it produces another unit of output. Also shows change in TVC from an extra unit of output. MC falls at first, and then rises as Q increases.	$MC = \Delta TC / \Delta Q$ $MC = \Delta TVC / \Delta Q$ because the only part of TC that changes when more Q is produced is TVC.

Reminder: The AVC curve is U-shaped (falls, then rises as Q increases) because its shape is the mirror image of the APP curve as shown in Activity 3-2. The MC curve also is U-shaped because it is the mirror image of the MPP curve. Refer back to Figure 3-2.5.

Table 3-3.2 is the cost spreadsheet for the Morton Boat Company. It has information on all seven short-run cost measures based on different Q levels of the firm.

- Complete Table 3-3.2. Some of the data have been posted for you already.



Table 3-3.2

The Seven Short-Run Cost Measures of the Morton Boat Company (daily data)

Q boats per day	(1) TFC	(2) TVC	(3) TC = TFC + TVC	(4) AFC = TFC/Q	(5) AVC = TVC/Q	(6) ATC = TC/Q = AFC + AVC	(7) MC = $\Delta TC / \Delta Q$ = $\Delta TVC / \Delta Q$
0				—	—	—	—
1	\$300		\$1,000				
2					\$650		\$600
3		\$1,800					
4				\$75			\$600
5	\$300					\$680	
6							\$740

- What trend do you observe in the value of TFC as the level of Q is increased? How do you explain this trend?
- What trend do you observe in the value of TVC as the level of Q is increased? How do you explain this trend?
- Compare the ATC value at any Q level with the MC value at the next Q level. What relationship do you see between ATC and MC?

9. Compare the AVC value at any Q level with the MC value at the next Q level. What relationship do you see between AVC and MC?

10. Compare the AFC value at any Q level with the MC value at the next Q level. What relationship do you see between AFC and MC?

Part C: Graphing the Cost Functions of a Firm

The relationships that exist among the firm's cost functions can be illustrated by plotting the data in Table 3-3.1 in cost graphs. Figure 3-3.1 is the "total" cost graph because it contains information about the firm's TC, TVC, and TFC functions. Figure 3-3.2 is the "marginal-average" cost graph because it shows the data for the firm's MC, ATC, AVC, and AFC functions.

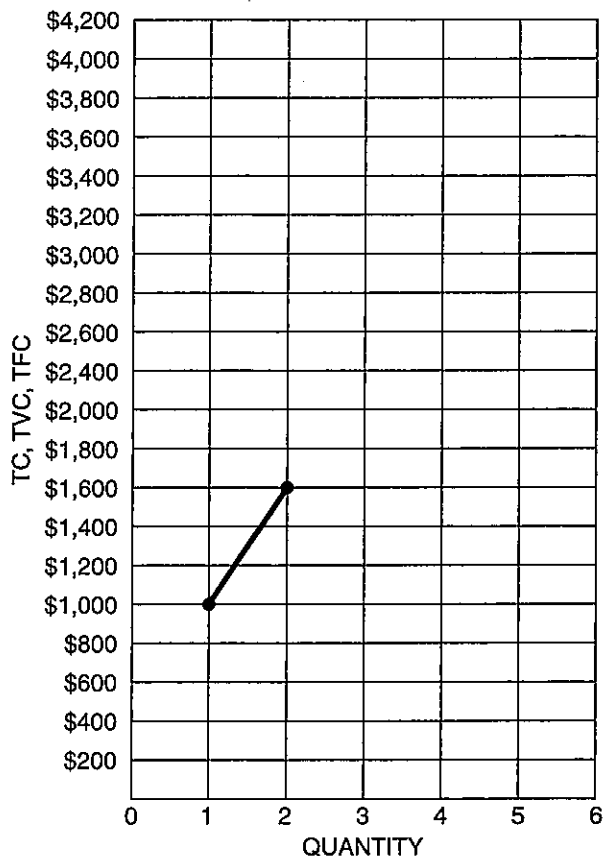
11. Plot the data from Table 3-3.1 in the appropriate graphs. Two observations of TC and AVC have already been plotted for you.

12. Plot the values of MC at the new output level. For example, put a dot on the graph at the combination of $Q = 4$ and $MC = \$600$ since the MC resulting from producing the fourth boat is \$600. Connect the MC dots in your graph with a dotted line.



Figure 3-3.1

The Firm's "Total" Cost Graph



13. Why is the vertical gap between the TC and TVC curves the same at all Q levels?

14. The slope of the TC curve can be expressed as $\text{rise/run} = \Delta TC / \Delta Q$. Do you know another cost function that is found using the ratio $\Delta TC / \Delta Q$?

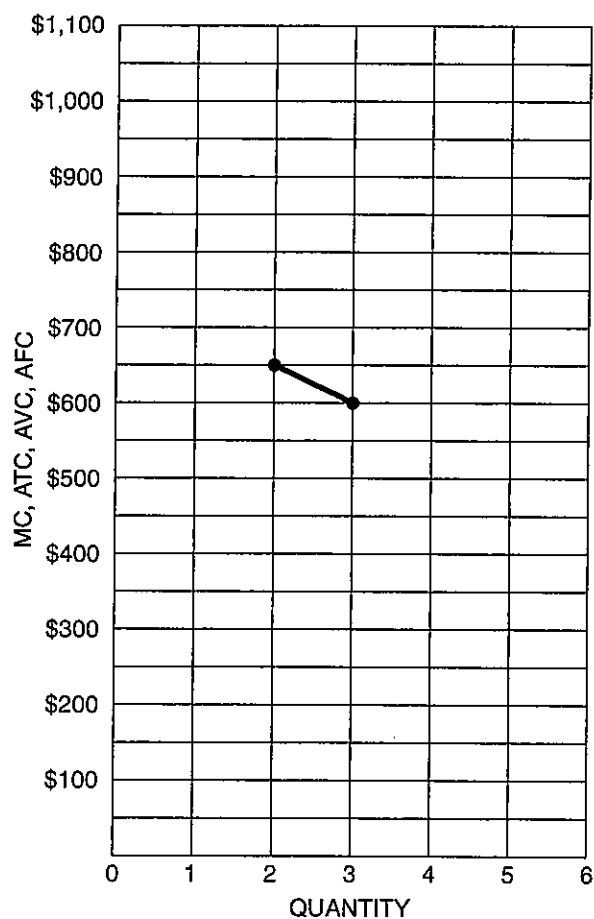
15. Why do both the TC and TVC curves keep climbing higher and higher as the Morton Boat Company increases the number of boats it produces?

16. Why does the TC curve not begin at the origin?



Figure 3-3.2

The Firm's "Marginal-Average" Cost Graph



17. AVC continues to decrease as long as MC is (*greater than / equal to / less than*) AVC.
18. AVC continues to increase as long as MC is (*greater than / equal to / less than*) AVC.
19. ATC continues to decrease as long as MC is (*greater than / equal to / less than*) ATC.
20. ATC continues to increase as long as MC is (*greater than / equal to / less than*) ATC.
21. Mr. Burpin, your AP teacher, asks you to explain the following statement: "Average fixed cost falls as long as marginal cost is less than average fixed cost." What is your response?

22. Do you agree with the following statement? "Average variable cost is minimized at the output level where marginal cost is equal to average variable cost." Explain.

23. What do you say to someone who says, "Fixed cost is the same at all output levels"?

24. Can you tell from Table 3-3.1 how many boats the Morton Boat Company should produce to maximize its total profit? Explain.

A Firm's Long-Run Average Total Cost Curve

The cost curves that we used in previous activities were the short-run cost curves of a firm. In the short run, a firm can vary its output by changing its variable resources, but it cannot change its plant capacity. In this activity we turn to the long run, defined as a time period in which all resources, including plant capacity, can be changed. In the short run, the shapes of the firm's average total cost (ATC) and marginal cost (MC) curves result from the principle of diminishing marginal productivity of resources. In the long run, the shape of the firm's long-run average total cost (LRATC) curve results from *economies of scale* and *diseconomies of scale*. Economies of scale explain why the firm's ATC decreases as it expands its scale of operations. Sources of economies of scale include specialization of resources, more efficient use of equipment, a reduction in per-unit costs of factor inputs, an effective use of production by-products, and an increase in shared facilities. Diseconomies of scale explain why the firm's ATC can increase as it increases its level of production. Sources of diseconomies of scale include limitations on effective management decision making and competition for factor inputs.

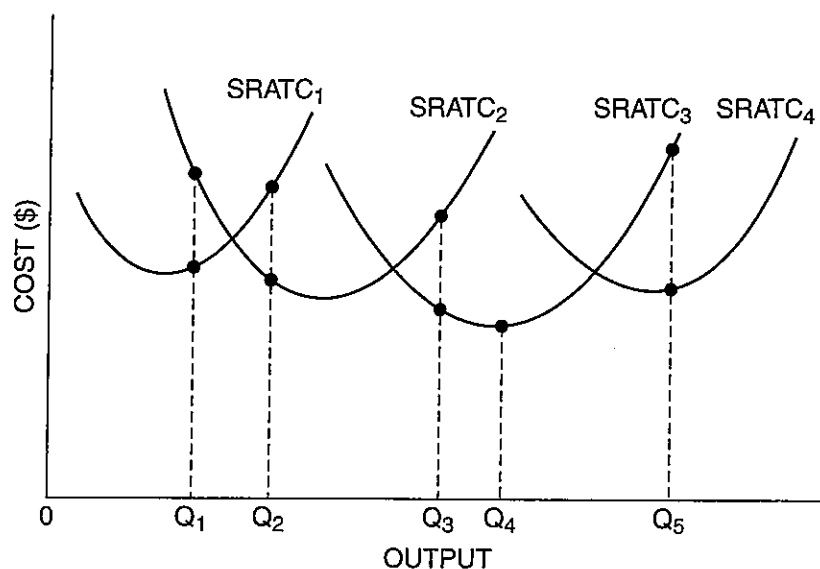
Part A: A Firm's Long-Run Average Total Cost Curve

A firm's LRATC curve shows the lowest ATC at which a firm can produce different levels of output when all inputs are variable. The LRATC is derived from a set of the firm's short-run average total cost (SRATC) curves. Figure 3-4.1 shows four SRATC curves for the Goodman Company, which is considering which of four different plant sizes it should use to produce various levels of output. Each SRATC curve represents the ATC of the firm as it produces output in the short run with a fixed plant size. As the firm increases its level of output, at some point it will need to increase its plant size. As it does so, we see that its SRATC falls as it moves from Plant Size 1 to Plant Size 2, and it falls again as it moves to Plant Size 3. As it moves to the larger Plant Size 4 to produce even larger output levels, its SRATC curve shifts upward. Note that the graph shows four SRATC curves of one firm, not one SRATC for each of four different firms.



Figure 3-4.1

A Firm's Long-Run Average Total Cost Curve



1. What does each of the SRATC curves represent?

2. At what output level in the long run will the firm minimize its ATC? Does this mean the firm will maximize its total profit if it produces this output level? Why?

3. The Goodman Company can produce output Q_1 with either Plant Size 1 or Plant Size 2. If the demand facing the firm is for this level of output, which plant size should the firm use? Why?

4. As the long-run demand for the company's product increases, it must decide which plant size is best as it tries to produce an output level at the lowest possible ATC. In the following chart, circle the firm's best plant size for these output levels.

Output level	Optimal plant size
Q_1	1 2 3 4
Q_2	1 2 3 4
Q_3	1 2 3 4
Q_5	1 2 3 4

5. Since the LRATC curve shows the lowest ATC at which different output levels can be produced, we can show it on Figure 3-4.1. Mark heavily the portions of each SRATC curve that will minimize the firm's ATC as the firm increases its scale of production. Label this heavily shaded curve as "LRATC."

Part B: Economies and Diseconomies of Scale

The opening section of this activity explained the concepts of economies and diseconomies of scale. They explain why the firm's LRATC curve slopes downward and then upward as the firm increases the scale of its production.

6. In Figure 3-4.1, as the firm increases its level of output from 0 to Q_4 , it is experiencing (*economies of scale / diseconomies of scale*).
7. As the firm increases its production level beyond Q_4 , it is experiencing (*economies of scale / diseconomies of scale*).

Part C: Returns to Scale

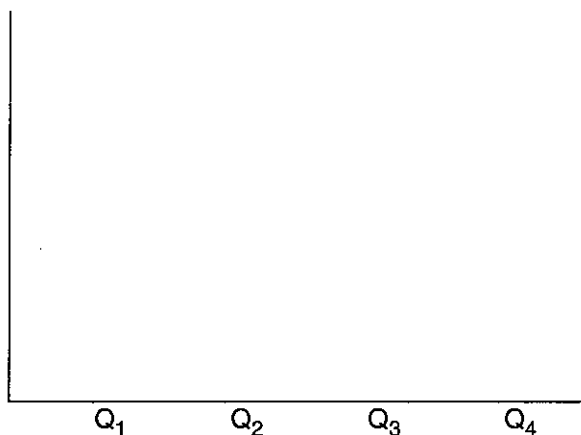
There are three concepts that are special cases of economies and diseconomies of scale where a firm increases all its inputs by the same percentage. A firm has *increasing returns to scale* if a proportionate increase in all resources results in an increase in output that is larger than the increase in resources. For example, if a firm increases all of its resources by 10 percent, and output increases by 14 percent, the firm experiences increasing returns to scale. *Decreasing returns to scale* are present if the increase in output is less than the proportionate increase in all resources. If output increases by only 7 percent when all inputs are increased by 10 percent, the firm has decreasing returns to scale. If output increases by the same proportion as all inputs were increased, the firm has *constant returns to scale*.

If we know the nature of the firm's returns to scale, we can determine what happens to the firm's ATC in the long run when it increases all resources by the same proportion. Since $ATC = TC/Q$, whether the firm's ATC increases, decreases, or stays the same depends on the resulting increase in output.

8. Assume the Goodman Company increases all of its inputs by 15 percent.
 - (A) Its total cost will increase by (*more than / exactly / less than*) 15 percent.
 - (B) If it has increasing returns to scale, its output will increase by (*more than / exactly / less than*) 15 percent, and its ATC will (*increase / not change / decrease*).
 - (C) If it has decreasing returns to scale, its output will increase by (*more than / exactly / less than*) 15 percent, and its ATC will (*increase / not change / decrease*).
 - (D) If it has constant returns to scale, its output will increase by (*more than / exactly / less than*) 15 percent, and its ATC will (*increase / not change / decrease*).
9. In Figure 3-4.2, draw the LRATC curve for a firm that experiences increasing returns to scale between output levels Q_1 and Q_2 , constant returns to scale between Q_2 and Q_3 , and decreasing returns to scale between Q_3 and Q_4 . Label the curve as "LRATC." Be sure to label the axes.



Figure 3-4.2
Returns to Scale



Revenue, Profit, and Rules to Maximize Total Profit

Now that you have explored the productivity and cost functions of a firm, you are ready to learn about its revenue and profit functions. It is important to note that the productivity and cost graphs look the same for any firm, regardless of whether the firm sells its output in a perfectly competitive, monopolistic, monopolistically competitive, or oligopolistic product market. Think of it this way: suppose you run a firm that produces computers. The productivity of your workers in your factory will determine your cost of producing computers. But now you are ready to take your computers from the factory and transport them to the product market to sell them. As we will see in subsequent activities, the shapes of your revenue functions will depend on how much competition you face in the product market. So although your productivity and cost functions are not affected by the product market, your revenue and profit functions will be. (We will see in Unit 4 that the factor markets for your resources will affect the prices you pay for inputs and thus will affect your cost functions.)

Part A: Revenue Terms

Student Alert: The distinction between total, marginal, and average measures is important!

There are three revenue terms you need to understand before you can answer questions about profit maximization. When a firm sells its product, the revenue it receives can be described in the three ways shown in Table 3-5.1.



Table 3-5.1

Three Measures of Revenue

Measure of revenue	Meaning	How to calculate
Total revenue (TR)	The total income the firm receives from selling a given level of output (Q) at a particular price (P)	$TR = P \times Q$
Average revenue (AR)	The revenue the firm receives from one unit at a given level of output	$AR = TR/Q$
Marginal revenue (MR)	The change in total revenue resulting from the firm selling one more unit of output	$MR = \Delta TR / \Delta Q$

The shapes of these revenue functions will depend on the type of product market in which a firm sells its good or service. The key point to watch for is whether a firm has to lower its price to sell more of its product. You will calculate values of these revenue measures and draw graphs of them in other activities where the type of product market is specified.

Part B: Profit Terms

In Activity 3-3 you learned the difference between accounting profit and economic profit. Since this book is preparing you to succeed on the AP Microeconomics Exam, it is time to focus on how a firm maximizes its total *economic* profit. A good habit to learn now is always to use the correct adjective in front of the word “profit”: total, average, or marginal. Accuracy counts when you are answering exam questions. (The same habit also should be applied to measures of productivity, cost, and revenue!)

There are three profit (Π) terms you need to master so you will understand the decisions made by a firm as it tries to maximize its *total* profit. When a firm sells its product, the profit (or loss) it receives can be described in the three ways shown in Table 3-5.2.



Table 3-5.2

Three Measures of (Economic) Profit

Measure of profit	Meaning	How to calculate
Total profit ($T\Pi$)	The difference between the firm's total revenue (TR) and total cost (TC) at a given level of output (Q)	$T\Pi = TR - TC$ $T\Pi = Q \times A\Pi$
Average profit ($A\Pi$)	The profit the firm receives from one unit at a given level of output (= per-unit profit)	$A\Pi = T\Pi/Q$ $A\Pi = AR - ATC$ $A\Pi = P - ATC$
Marginal profit ($M\Pi$)	The change in total profit resulting from the firm selling one more unit of output	$M\Pi = \Delta T\Pi/\Delta Q$ $M\Pi = MR - MC$

Note: While some college textbooks do not introduce the concept of marginal profit, it is a useful concept as you explain why a firm should (or should not) sell an extra unit of output.

Here's another useful hint: Be careful about mixing “totals,” “averages,” and “marginals.” Look again at the three basic ways to calculate the measures of profit:

- Total profit = *total* revenue – *total* cost.
- Average profit = *average* revenue – *average* total cost.
- Marginal profit = *marginal* revenue – *marginal* cost.

Part C: Key Rules for Any Firm to Follow

Economists assume firms try to maximize their total profit. This means a firm must decide how many units of its good or service to produce and what price to charge for that product. Fortunately, there are several basic rules that apply to any firm as it makes these decisions. At this point, we will give a general overview of the rules. You will work in detail with each rule as you move through other activities for firms in different types of product markets. Although the basic rules apply to all firms, the different levels of competition in the various markets will require that you stay focused to help the firm make the correct decisions.

Rule 1: A firm should produce the output level at which $MR = MC$.

This rule sounds so simple, but many students never really understand it (although many memorize it). How can producing a unit for which $MR = MC$ maximize total profit? After all, doesn't $M\Pi = \$0$ for that unit? Yes, and ironically, that is why the rule works. Look at Table 3-5.3 which has information about the Sosin Company.



Table 3-5.3

The Sosin Company

Output units	MR compared to MC	MΠ	TΠ
1–499	$MR > MC$	$M\Pi > \$0$	TΠ increases.
500	$MR = MC$	$M\Pi = \$0$	TΠ has reached its peak.
501 and beyond	$MR < MC$	$M\Pi < \$0$	TΠ decreases.

If $MR > MC$ for the first 499 units, the firm certainly wants to produce all of them. These units create positive $M\Pi$, which means $T\Pi$ increases with each additional unit. What does the 500th unit do for the firm's $T\Pi$? Nothing at all. The $M\Pi$ of the 500th unit is $\$0$ because its MR is equal to its MC . But check out units beyond 500. Each of these units adds less to TR than it adds to TC (or, $MR < MC$). If the Sosin Company produces these units, each unit will have a negative $M\Pi$, which means $T\Pi$ will decrease, and the firm does not want that to happen.

So what is so special about the 500th unit where $MR = MC$? The answer is surprisingly simple. If the firm produces 500 units, it has produced all the units that increased its $T\Pi$ ($M\Pi > \$0$) and stopped before it produced any units that would decrease its $T\Pi$ ($M\Pi < \$0$). The 500th unit itself had no effect on $T\Pi$, but economists like the simple " $MR = MC$ " rule as an efficient way to locate the output level that will maximize a firm's $T\Pi$.

Rule 2: A firm should charge the price on the demand curve for its optimal output level.

Suppose your boss offers you a \$5 per hour pay raise. Are you going to decline that offer? Of course not! You want to get the highest pay you can for your labor. A firm is no different. Once it decides on the optimal number of units of its product (where $MR = MC$), it wants to receive the highest possible price for that output level. And that is exactly the information the firm gets from its demand curve. Basically, it will go up to the demand curve at its optimal output level and hang a direct left to the vertical price axis.

Rule 3: A firm should shut down and produce zero output if TR is less than total variable cost (TVC).

Unfortunately, there are times when a firm cannot earn a positive total profit. Perhaps the high prices of resources have made the firm's production costs unprofitably high. Or perhaps a downturn in the economy has so reduced demand that the firm cannot get a profitable price for its product. When a firm earns a negative total profit at its best output level, it has two choices in the short-run: It can go ahead and produce that output and accept the loss, or it can produce no output at all (shut down).

Here is the rule the firm should follow: If its TR is greater than its TVC , it should produce its optimal output (where $MR = MC$) rather than shut down.

Here's the logic behind this rule:

- If the firm shuts down ($Q = 0$), it will have no TR or TVC , but it will still have its total fixed cost (TFC). Thus, by shutting down, the firm is committed to a loss equal to its TFC ($\text{loss} = TFC$).
- If the firm produces its best output and has TR that is less than TVC , then the firm will make a loss on its variable resources and still have all of its TFC . Its loss will be larger if it produces than if it shuts down ($\text{loss} > TFC$).
- If the firm produces its best output and has TR that exceeds TVC , then after it pays all its TVC the firm has some leftover TR to apply toward its TFC . This will make its loss less than its TFC ($\text{loss} < TFC$).

Part D: Do You Get It?

Here are some questions to see if you understand the revenue and profit terms and the three key rules to maximize total profit. Circle "T" if you feel the statement is true and "F" if you think it is false. Explain your answer for each statement.

T F 1. If a firm sells 200 units of its product at a price of \$8, its total profit will be \$1,600.

T F 2. If the average revenue from 150 units is \$20, the firm's total revenue is \$3,000.

- T F 3. If the marginal revenue from the twenty-first unit is \$30, then the total revenue from 22 units is \$30 greater than the total revenue from 21 units.
- T F 4. As long as MR is greater than MC, a firm's TPI will increase if it increases its level of output.
- T F 5. When MPI is \$0, we know TPI also is \$0.
- T F 6. If MPI is negative, a firm's TPI will increase if the firm produces fewer units of output.
- T F 7. At its current output level, the Placone Firm has $AR = \$12$ and $MC = \$10$, which means its $API = \$2$.
- T F 8. A firm determines it will maximize its total profit by producing 800 units per week because at that output both MR and MC are \$600. The price the firm should charge for its output also is \$600.

Answer Questions 9 and 10 based on this information: The Wright Company estimates the following values at its optimal level of output: $TR = \$20,000$, $TVC = \$18,000$, and $TFC = \$5,000$.

- T F 9. This firm should shut down rather than produce its optimal level of output.
- T F 10. If its optimal output is 5,000 units, the price it charges for its good is \$4.00.